Journal of the Royal Society of Western Australia, 77: 179-180, 1994

Future ecosystems — use of genetic resistance

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Abstract

Genetic resistance of jarrah to *Phytophthora cinnamomi* has been identified by glasshouse testing and validated by field trials and analysis of plant/pathogen interactions. Resistant lines of jarrah can be micropropagated and used for revegetation of bauxite mine-sites and have potential for use in replanting dieback graveyard areas in the forest. Experiments are underway to determine the level of resistance of the progeny of selected resistant trees. Several questions are posed in this paper on the use of genetically resistant plants in restoring ecosystems.

Introduction

We have shown that it is possible to select *Eucalyptus marginata* (jarrah) resistant to *Phytophthora cinnamomi* and that this resistance is genetically based. A number of jarrah trees were selected on the basis of their apparent field resistance or susceptibility to *P. cinnamomi*, or because they represented an ecotype of jarrah. At 12 months of age, half-sib seedlings were screened for their reaction to the pathogen using underbark inoculation or by inoculating the soil. The mean lengths of the lesions, or the percentage of plant deaths, were used to rank families (*i.e.* progenies from individual open-pollinated mother trees) from most resistant to most susceptible (Stukely & Crane 1994). From the extremes of the range, highly resistant plants from resistant families, and susceptible individuals from susceptible families were chosen and micropropagated (McComb *et al.* 1990).

The clonal plants were planted in dieback-affected sites on rehabilitated bauxite pits and were inoculated with 4 strains of the fungus 1 month after planting. After 5 years in a typical field trial, the resistant plants have shown a low number of deaths and excellent growth, while in some susceptible lines all the plants have died (Fig 1).

Laboratory testing of the selected plants has shown that, after infection of root tips with zoospores, the resistant jarrah plants confine the lesion extension; this was also observed in roots of the field resistant species *E. calophylla* (Cahill *et al.* 1992). Further work is underway to investigate the mechanism of this resistance and its interaction with environmental variables such as temporary waterlogging (Cahill & McComb 1992, Cahill *et al.* 1993).

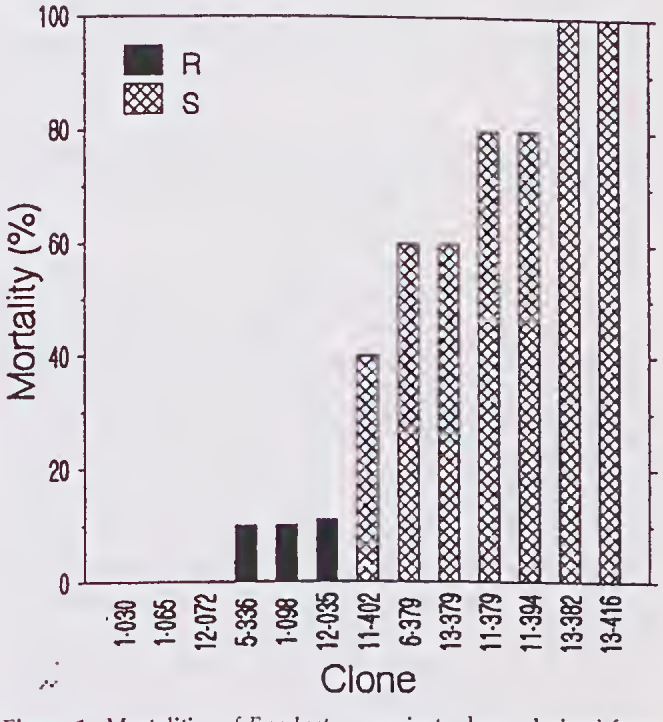

Figure 1. Mortalities of *Eucalyptus marginata* clones derived from seedlings resistant (R) and susceptible (S) to *Phytophthora cinnamomi*, after 5 years of growth in a *Phytophthora*-infested bauxite mine-site.

Heritability of resistance to *P. cinnamomi* was estimated from analysis of mortalities after soil inoculation in pots and in the field, and from stem lesion lengths after underbark inoculation of 15 - 50 half-sibs from each of 16 families (Stukely & Crane 1994). Resistance to *P. cinnamomi* was found to be under strong genetic control as narrow-sense heritability for the families was 0.74 - 0.85 and for individual trees was 0.43. We are studying the inheritance of the resistance trait further by controlled crosses and will gain information on other characteristics such as flowering times and combining ability for resistance.

Symposium on Plant Diseases in Ecosystems:
Threats and impacts in south-western Australia.
Held on April 16, 1994, at Murdoch University, by the Royal Society of Western Australia and the Ecological Society of Australia.

Can genetic resistance to *P. cinnamomi* help restore damaged ecosystems?

It is important to investigate the use of resistant clones of jarrah to re-establish the species in areas in which it has died from dieback, that is on graveyard areas. This will be a greater challenge than the establishment of clones in bauxite pits where root competition is absent, drainage is optimised and the soil is friable. We have yet to develop reliable techniques for establishing micropropagated plants in graveyard areas where jarrah plants have to be inserted between existing vegetation, and it is not possible to provide the same level of site preparation as in bauxite pits.

In the ideal situation, the trees that are used in graveyard plantings will eventually establish a self-sustaining population of largely resistant trees. This will only be possible if we can identify clonal lines with good combining ability for resistance, and these lines flower at the same time.

In restoring a damaged ecosystem we feel it is necessary to utilise, as far as possible, genotypes from the surrounding forest. With this in mind we are now doing further selections from the northern and southern regions of the jarrah forest. However, jarrah is just one species which is killed in natural ecosystems. Replacing the jarrah is a small step towards reversing the floristic impoverishment of the affected areas.

Can the method used for selection of resistant jarrah work for other species and other diseases?

Theoretically it would be possible to screen other plants with *P. cinnamomi* or other pathogens and to find resistant individuals in the field. However, on some forest sites jarrah is relatively resistant to *P. cinnamomi* (Dell & Malajczuk 1989) compared with many other species, in which there may be 100% deaths. There are problems too, not only with the vast number of species that are affected in each ecosystem, but also the length of time required to work out reliable propagation or micropropagation methods for some species, and to develop appropriate screening methods. Clearly it is a strategy only suitable for priority species. It may be possible to partially restore an ecosystem by use of selected resistant lines of a restricted number of species. This would at least provide more diversity of plant species and animal habitats than are found at present in graveyard areas.

Can the new techniques of genetic markers or probes make selection of disease resistant plants faster?

In some plant / pathogen interactions it is now possible to identify disease resistant plants by extracting the DNA and probing it for DNA sequences known to indicate resistance. It is not necessary to know the mechanism of the disease resistance and the technique allows screening of plants from disease free areas and of plants whose propagation is difficult.

This exciting development must be underpinned by initial work in each species to identify some resistant and susceptible lines and some study of the heritability of resistance. However, once appropriate markers are found, screening for suitable resistant individuals for seed orchards, vegetative or micropropagation can proceed more rapidly. The technique is likely to work most quickly when there are major genes for disease resistance, but it may also be effective in polygenic systems of resistance such as in jarrah.

Can natural resistance be enhanced or replaced by genetically engineered resistance?

Genetic engineering offers almost unlimited scope for introducing novel mechanisms for disease resistance into plants. In practice, the problems of working out appropriate techniques for introducing new genetic material into a number of species in a natural ecosystem are immense and consequently very costly. Added to this are ethical problems. There may be few objections when the introduced gene is from a resistant plant of the same species, but we might expect objections when genes from unrelated organisms are used.

Genes introduced by genetic engineering may come from unrelated organisms and in recipient species they form new loci usually dominant in expression. In a cross-pollinating species with a short generation time and under high selection pressure, the gene would spread quickly through the population. Are we willing to see this type of genetic engineering in our natural ecosystems? Is the damage from *Phytophthora* and other pathogens so great that we would be willing to make the natural ecosystem , to some extent, unnatural ?

Acknowledgment: We thank Alcoa (Aust) for their continuing support for the work on selection and propagation of dieback resistant jarrah.

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